The study of fossil ferns

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On first thought it may seem that the student of living ferns has many advantages over the student of fossil ferns—and so, indeed, he has—but when a close analysis is made of the two fields the advantages appear somewhat less striking. The student of living ferns, if he collects his material in the field, has the opportunity of examining it to the minutest detail, from the ecological conditions under which it grew, its internal anatomy and development, to its frond outline, nerve characters, and fruit production. If it be worth while it may be grown artificially through its complete life cycle back to the spore-producing stage again. Yet, in spite of this seeming perfection of detail, all students well know the differences of interpretation that constantly arise. From the limits of families, genera and species, to the faintest subspecies and hybrid, there are, or may be, opposing views.

When a botanist without previous experience along these lines views a collection of fossil ferns he is very apt to say, that, beyond the fact that they appear really to be ferns, little or nothing can be done in the way of correctly placing them, even generically. But to the paleobotanist the problem is by no means so hopeless. Long experience, coupled with a knowledge of living forms, has taught him the value of characters often overlooked or subordinated in the study of fresh material. Habit, outline, and nervation are the characters that must principally be relied upon in the study of fossil ferns. For instance, the genera *Acrostichum*, *Onoclea*, *Woodwardia*, etc., have a nervation so peculiar and characteristic that they can be identified easily and readily, and a number of fossil species have been described from this

country under these genera. Fruiting specimens are always sought and are of course of the greatest value in placing fossil forms. From these characters the following genera have been determined in the later horizons with great accuracy: *Dryopteris*, *Asplenium*, *Onoclea*, *Woodwardia*, *Adiantum*, *Dennstaedtia*, *Onychium*, and many others. From their characteristic form, combined with the characters of nervation, the genera *Lygodium*, *Gleichenia*, and *Sagenopteris*, have been determined, while in exceptional cases the internal structure has been found silicified so that thin sections have been cut and studied as successfully as though it were living; such was the *Osmunda*-like form recently described by the late Prof. D. P. Penhallow.

After all have been segregated that admit of identification on the basis of characteristic outline, nervation, or fruiting character, there remains a considerable number named in accordance with what seems to be their apparent affinity or relationship. Thus, a fern having certain of the fruit characters of the living Schizaeaceae, but not agreeing with any known living species, has been called *Schizaeopsis*. This attempt at seeking for affinities among living ferns becomes increasingly difficult as we go backward in time, until ultimately a point is reached in the geological scale where the fossil ferns present are without known or obvious living representatives. Many genera—form genera, they may be called—and higher groups have been founded for forms that cannot at the time be more definitely placed, but every now and then a specimen turns up that in a moment serves to interpret one of these genera or families in its relations to the living flora. For this reason alone it is worth while to study and name all fossil ferns, whether they can be correctly allocated among living ferns or not, for the light they may throw on the evolution of the great group to which they belong, as well as for the marks they

may supply for the use of the geologist. Right here is a point likely to be overlooked by the botanist. Unless a fossil fern can be placed with reasonable biological accuracy, the botanist is rather prone to look upon its study as useless, or at least as not worth the time expended in naming, describing, and figuring it. But paleobotany has two distinct phases or fields of study, the biological and the geological, depending upon the prominence to be given to the one or the other of these subjects. The paleobotanist does the very best he can in correctly placing a fossil fern in its relation to the living flora, though not infrequently he may make mistakes, glaring mistakes; but whether he does or not is not of the slightest importance to the stratigraphic geologist so long as the fossil is from a known horizon and is clearly defined and capable of being recognized under any and all conditions. That is to say, if an important coal bed or other geological horizon has associated with it always a particular and readily recognized fern, or group of ferns, it makes not the slightest difference to the geologist whether they are correctly or incorrectly named, and they might even be referred to by number. As Prof. J. W. Judd once said: "We still regard fossils as the 'medals of creation,' and certain types of life we take to be as truly characteristic of definite periods as the coins which bear the image and superscription of a Roman emperor or of a Saxon king." It is for this reason that so many fossil ferns that have not been placed biologically, have been described in this country; for, be it known, there is no country in the world in which paleobotany has the recognized standing as an aid to geology that it enjoys in North America.

The question is often asked as to how and where fossil ferns are found. As a matter of fact, they are found from almost the most ancient rocks in which vegetation of any kind occurs on down to the present time. Long

experience has taught the paleobotanist the horizons and kinds of rocks in which they are most likely to be found; but there is no general rule, for rocks heretofore barren may today be shown to contain them in abundance. It is simply a question of searching, and no likely rocks should be passed by. As ferns for the most part are delicate in structure, only certain kinds of rocks are fitted to preserve them in any degree of perfection. Thus, a coarse sandstone or conglomerate would not be likely to retain them so that the characters can be satisfactorily made out. Fine-grained clay shale is the matrix in which they are preserved to the best advantage, and in this even the most delicate are often revealed to the minutest detail of outline, nervation, and even the spore-cases and spores.

The ferns and fernlike plants of the Carboniferous, or the great anthracite coal age, are present in wide variety and perfection. They grew in tropical profusion in and about the great, shallow, low-lying swamps of that time, and their remains, together with the remains of allied types of vegetation, fell into the water where they underwent only partial decay, the continued accumulation ultimately making up the beds of coal. That the ferns were abundant is shown by the fact that in numerous places layers of considerable thickness, compressed to the specific gravity of coal, are made up almost entirely of spores. It occasionally happened then, as may be observed about any marsh or shallow pond of today, that an especially high flood or a broken barrier of some sort admitted silt or clay in suspension, which was deposited and now forms the shale partings in the coal or layers above it. These are usually the best places to look for ferns, for as the plants are not present in such great numbers, the details can be made out more satisfactorily. The U. S. National Museum possesses a single collection, the gift of a generous patron, the late Mr. R. D. Lacoe,

of Pittston, Pennsylvania, of not far from 100,000 specimens of coal plants, a majority of which are ferns. Some of these are truly magnificent specimens, showing that there were tree ferns then existing with fronds that must have spread a dozen or twenty feet, as well as a host of smaller forms.

The digging out and collecting of fossil ferns is very interesting, not to say exciting. There is always the possibility before one that the next blow of the hammer may bring forth something new and wonderful, the like of which has never been seen by mortal eye. Perhaps it may be a wholly new type, or possibly a fruiting specimen that will settle for all time the position of a group previously unplaced. A case of the latter once fell to the lot of Mr. David White, of the U. S. Geological Survey. He was collecting Carboniferous plants at Nuttall, West Virginia, when a fortunate blow revealed a delicate "fern," since named *Aneimites fertilis*, which had seeds attached to the tips of its reduced pinnules, and on the instant a great group of supposedly true ferns was transferred to the then newly discovered group of pteridosperms, the first to be recorded for this country. Other similar discoveries had preceded and have followed this, in England and France, and now it is well known that the seed-bearing habit had been acquired by "ferns" long ages before the advent of flowering plants.

One of the most interesting experiences of the writer in collecting fossil ferns was near Cumberland, Uinta county, Wyoming. It appears that in 1843 Capt. John C. Fremont, when on one of his exploring expeditions to the Rocky Mountains, collected a handful of delicate fossil ferns from near what is now known as "Oyster Ridge." A grave dispute arose as to the geological age of the beds containing them, but they were not rediscovered until 1906, and a couple of years later the writer made a special trip to the locality. They were

found as Fremont described, in a conspicuous bed of hard white clay which runs for miles along a steep hillside. The first blow of the hammer proved that it was really the fern horizon and in feverish haste we dug out and split open the layers of clay. There were beautifully preserved and delicate little fronds of *Gleichenia* of several species, some so perfect that the characteristic forking of the fronds and the apical bud were well displayed. There was a fine large fruiting species of *Anemia*, a peculiar *Dennstaedtia* with the fruit borne on reduced pinnules, as well as a number of types without fruit. It was a fine array that we packed and shipped to Washington, where it still awaits opportunity for final study. The same association has since been found in other parts of Wyoming, but none of it has been critically examined.

Briefly recapitulated, the reasons why it it worth while to study fossil ferns are: (1) It not only adds to the sum total of knowledge, but it furnishes, or at least may often supply, valuable data on the evolutionary history of the group; (2) data bearing on the temperature and moisture, as well as on other ecological conditions, are supplied; and (3) the study affords an invaluable series of stratigraphic marks for the use of geology.

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